Eastburn-Jeanes Limekilns, circa 1820-1850 HAER DE-2
Newark
New Castle County
Delaware

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D. C. 20240

HISTORIC AMERICAN ENGINEERING RECORD

Eastburn-Jeanes Limekilns

HAER DE-2

Location:	Newark, Delaware Vicinity UTM: 18.438100.4399280 18.438800.4399060 Quad: Newark East
Date of construction:	c. 1820-1850
Present Owner(s)	Hugo Poppy and John L. Brill, Paper Mill Road, Newark, Delaware. Carl Herber, Pike Creek Road, Newark, Delaware.
Significance:	The limestone/marble deposits in the Pike Creek Valley of New Castle County are the largest in the State of Delaware. During the first third of the 19th century they became the center of an extensive commercial lime-burning industry which continued for over 85 years. By the 1830s, the Jeanes and Eastburn families had opened two quarries and erected a number of limekilns. The rapid growth of demand for lime as fertilizer and mortar made the Eastburn enterprise a profitable one until eclipsed by larger, more efficient suppliers after 1900. The site reflects the growth and organizationof lime burning from a supplementary agricultural pursuit to a commercial operation. Eight of the original limekilns remain, as do the quarries and a number of auxiliary structures which comprised the Eastburn-Jeanes lime-burning complex in the early 19th century.
Historian:	Raymond W. Smith, 1976.

During the 19th century burnt lime, or calcium oxide, was a commodity valued for its numerous industrial applications. As a building material, lime mixed with water was used as interior plaster. Lime had also been recognized since Roman times as an essential ingredient in the making of mortar and hydraulic cement. [1] The quality of Delaware limestone as a building material was recognized early in the 19th century. A geologic survey of the state published in 1841 noted, "the limestone found in the upper part of the state, yields an excellent mortar, when well burned and freshly slacked; and with proper care, one bushel of burnt lime will more than double its bulk." [2] However, burnt lime became most important before the Civil War as an inorganic fertilizer.

The early impetus to fertilize with lime was provided by southern agriculturist Edmund Ruffin. As early as 1818 Ruffin began experiments with the application of marl to depleted, acid, soils in his native Virginia. At harvest time, Ruffin's marled lands yielded a crop 40% greater than fields which had not been thus fertilized. Ruffin correctly concluded from these spectacular results that alkali, by neutralizing accumulated vegetable matter, restored balance and fertility to farmland. In 1821 he published his findings in the American Farmer; and, in a form subsequently revised and expanded, Ruffin's Essay on Calcareous Manures went through five editions by 1852. [3] Ruffin's advocacy of lime as fertilizer preceded by two decades the first American edition (1851) of Justus Liebig's classic Chemistry and its Application to Agriculture and Physiology. Liebig encouraged farmers to replace needed soil constituents by liming their fields, and Liebig and Ruffin, together, exerted a profound influence upon American agriculture in the ante-bellum era. [4]

Lime burning in early American began as one of the farmer's late winter tasks. Limestone was burned (or calcined) for several reasons: As the stone was slowly heated, carbonic acid was driven off, leaving a rather pure calcium oxide. The burning of limestone also reduced the bulk of the calcium as impurities were removed, so lime could be transported and applied more efficiently.

The use of lime as fertilizer was widely known and rapidly expanding by the 1830s. Initially, farmers used lime far in excess of its real efficiency, because they little understood its chemical action. Soon those beyond the immediate vicinity of lime deposits began to recognize the value of agricultural lime, and many farmers started burning and marketing lime to supplement their incomes. [5]

It is in this context of growing interest in lime and its uses that the Eastburn-Jeanes lime-burning enterprise expanded to commercial scale in the first half of the 19th century.

Growth of a Local Industry

The commerical lime-burning industry in Pike Creek Valley began in 1816, when a prosperous landowner, Abel Jeanes, began quarrying and burning lime on the site. The Jeanes farm, occupying an extensive tract of land along Pike Creek, included the largest outcroppings of native limestone in Delaware. Using this stone as a building material Jeanes constructed a massive barn, a double tenant house, a springhouse, a combination warehouse and gristmill, and a large dwelling house of both stone and brick. [6]

Sometime after 1812, David Eastburn joined Abel Jeanes in his large-scale farming operation. In 1800, Eastburn had emigrated to Milltown, Delaware from Bucks County, Pennsylvania. On 3 December 1801 he married Elizabeth, sister of Abel Jeanes. Soon after the War of 1812, Eastburn purchased land adjoining the Jeanes property on Pike Creek, and he established a farm of his own. Little is known of David Eastburn's agricultural activities in Pike Creek Valley. He died in 1824, leaving a widow and 14 children. His eldest son, Joseph Eastburn, first recognized the full potential of the limestone quarries and developed the lime-burning activities from an agricultural task into a profitable commercial venture. [7]

Conditions in Pike Creek Valley favored the growth of the Eastburn-Jeanes lime-burning enterprise. Geologically, the stone of New Castle County was the finest obtainable in the state for processing commercial and agricultural lime. A contemporary assessment of 1841 observed:

> [Limestone] . . . occurs in . . . abundance at Jeanes' and Eastburn's on Pike Creek, and in smaller quantity at Klair's, 2 miles W. of Centreville, and at Bullock's, near the crossing of the state line by the Brandywine. It is a pure marble, essentially composed of lime, magnesia, and carbonic acid, with a small amount of foreign matter. It is a coarse and fine-grained crystalline mass, with a white color of greater or less purity, presenting at times a bluish tinge from the presence of carbonaceous matter. It lies in heavy beds, generally disintegrated in its upper layers, and giving rise to a calcareous sand near the surface of the ground. [8]

The bluish calcareous stone found in Pike Creek Valley was the preferred type, because it yielded commercial burnt lime of the highest quality. [9]

A second major advantage of the Pike Creek location was the abundance of timber that could be cut to fire the limekilns. To supplement his own extensive timber holdings, Joseph Eastburn acquired cutting rights to large adjoining tracts of timber. Horses and oxen hauled firewood from the various woodlots to the kilns. [10]

With an abundant supply of raw materials nearby, Joseph Eastburn and Abel Jeanes opened additional quarries and erected numerous stone kilns during the 1820s and 1830s. A local historian noted that during this period seven kilns on the Eastburn farm and ten to twelve limekilns on the Jeanes property were in operation. Supplementing this already large capacity were a number of scattered limekilns operated by individual members of the large Eastburn family. [11] The constant burning of lime in so many kilns allowed the business to be conducted on an industrial scale.

The magnitude and rapid growth of the Eastburn-Jeanes lime operations in the early 1830s is discernible from data on Delaware manufactures compiled and reported to Congress in 1832. The lime industry in Pike Creek Valley as managed by Abel Jeanes and Joseph Eastburn had a total capital investment of $70,000 in buildings, grounds, and machinery. Jeanes employed 25 to 30 men; Eastburn, 14. Since 1816, the combined operation produced 85,000 bushels of burnt lime from 95,000 bushels of quarried limestone, a very high yield. The kilns were kept in constant operation throughout the year, and the sale of their product was brisk. [12]

The rapid growth of the demand for agricultural lime in the late 1830s met major obstacles in the lack and prohibitive cost of land transportation for such a bulk commodity. For many years these factors impeded the expanded use of lime in agriculture outside the immediate vicinity of the kiln. [13] To take full advantage of the lucrative agricultural market for his product, Joseph Eastburn had to take his lime from the kilns to the farmer. Toward this end the enterprise began to maintain its own pool of horse and ox-drawn wagons for hauling burnt lime. In 1832 there were 38 draft horses and ten or eleven yoke of oxen available for this work. [14] As the undertaking achieved a commercial scale, Joseph Eastburn added several limestone structures to the Pike Creek Valley complex, including a wheelwright's shop, an office and storeroom, and a wagon shed. The kilns at first supplied only local needs, but Pike Creek Valley lime was soon being delivered as far south as Middletown, Delaware, and Chesapeake City, Maryland

(the western terminus of the Chesapeake & Delaware Canal); and as far north as Lancaster, Pennsylvania, where German farmers were innovators in the use of lime fertilizer. [15]

Economies of scale appear to have affected the price of Eastburn-Jeanes lime. In 1835, burnt lime in southeastern Pennsylvania sold for 25-35¢ per bushel (approximately 80 pounds) at the kiln. A similar price situation existed in Delaware. Abel Jeanes reported that prior to 1822, his lime sold for 30¢ per bushel; after that date the price fell to 20¢ at the kiln. The price per bushel decreased as the quarrying operation grew, new kilns were erected and production of burnt lime increased. In 1832 Eastburn noted a constant decline in the costs of labor and materials since the business was established in 1816. [16] There is no evidence of a barter system between the Eastburn-Jeanes interests and consumers of their product: all sales appear to have been on a cash basis.

With the bulk of its trade in agricultural lime, the Eastburn-Jeanes business continued to prosper throughout the 19th century. Prior to the Civil War, many farmers opposed the idea of liming their fields. But as they came to better understand soil chemistry and the function of agricultural lime, farmers steadily began using the material in increasing amounts.

By 1850, with the hope of increasing its output and efficiency, the Pike Creek lime enterprise partially converted to coal as the fuel for its kilns. [17] By 1900, however, the local industry was eclipsed by the development of modern blasting and quarrying techniques which facilitated the opening of large limestone quarries in Pennsylvania, Western Maryland, and the Shenandoah Valley of Virginia. [18] The use of large banks of commercial kilns and coal fuel in the lime burning process gave large firms economies of scale over localized operators such as Eastburn. Finally, rail transportation from the quarry regions facilitated the hauling of bulk lime to the consumer, thereby eliminating the major cost factor in the lime industry.

A victim of technological and economic change, the Eastburn lime-burning industry in Pike Creek Valley ceased its operations during the first decade of the 20th century. Eight limekilns and two abandoned quarries, together with the stone buildings erected by Abel Jeanes and Joseph Eastburn stand as reminders of the extensive local lime industry.

The Limekiln: Function and Construction

Limestone is a class of rock consisting mainly of calcium carbonate. The burning or calcining of lime is a heat-induced reaction wherein the chemical bond between calcium oxide and carbon dioxide is broken:

Calcium Carbonate + Heat = Calcium Oxide + Carbon Dioxide
(Limestone) (Lime) (Gas)

$CaCO_3$ + Heat = CaO + CO_2

This chemical change within the limekiln which yielded quicklime. Depending upon its intended use, quicklime was sometimes converted to slaked or slacked lime, (calcium hydroxide, $Ca(OH)_2$) [19] by adding water at its final destination. Slaking increased the bulk of the lime by more than 1/3, rendering it more efficient for use in mortar or as plaster. For agricultural use as fertilizer, however, newly-burned quicklime was essential. A contemporary treatise advised farmers, "Care should always be taken to procure this article as fresh and as perfectly burnt as possible, as short a time as possible before it is made use of, as lime when only just taken from the kiln can be said to be pure, for immediately on its removal it begins to absorb the carbonic acid gas of the atmosphere, and to resume its original state of carbonate of lime." [20]

Burning lime in a kiln initially drove off water and some carbon dioxide. Prolonged burning at sustained red heat was necessary to liberate the remaining carbonic acid, yielding a pure calcium oxide. [21] It was therefore essential that the limekiln be designed and built to incorporate the desired characteristics for slow, sustained burning while consuming minimum fuel.

Limekilns were erected near a limestone quarry or the source of fuel. The location of the Eastburn-Jeanes kilns in Pike Creek Valley incorporated both conditions, which contributed to its success by limiting the need for transportation of raw materials. The earliest type of kiln was the stack, or field kiln, in which broken limestone was piled on a stack of wood, sealed over with mud or clay, and ignited. Early in the 19th century a more permanent structure was developed - the intermittent kiln, which had square or circular retaining walls of fieldstone. Inside the kiln, an arched charge of limestone was placed over a pile of wood fuel. While it represented a slight advance over the stack kiln, the intermittent kiln had several disadvantages of its own. It depended heavily on abundant cheap fuel and labor. It wasted heat and fuel.

Each charge in the kiln had to burn out and cool down before the lime could be raked out. Consequently, the subsequent charge had to be loaded into a kiln that was literally "stone-cold." [22]

The most efficient limekiln to appear in the early 19th century was the "perpetual kiln." It was erected, with a number of minor variations, on the Eastburn and Jeanes farms from 1816 to 1850. The perpetual kiln, once ignited, could be recharged continually, saving more fuel than the intermittent kiln. Lime could likewise be "drawn" from the kiln periodically, while charge after charge of limestone was slow-burned and charged into quicklime.

A perpetual kiln built into a hillside used the slope to facilitate charging the kiln with cartloads of limestone and fuel from above. The hill also served as a windbreak, preventing cross-winds and sudden drafts from interfering with the burning process inside the kiln. [23] Often the front walls of the kiln were extended to follow the contour of the hill, acting as a retaining wall for the earth alongside the hearth.

The extant Eastburn-Jeanes limekilns vary in size and outward appearance, but all are similar in structure and function. The perpetual kiln appears circular in plan. The "pot" or kiln shaft, in a vertical section appears as an ellipse, truncated at top and bottom. The diameter of the pot is approximately eight feet at the top and tapers to five to six feet at the hearth. The elliptical shape utilized reverberatory heat, and the "boshes," or curved kiln walls facilitated downward settling of the lime as it burned.

The hearth or "thimble" is an opening six to ten feet high and nearly equal in width, with an arched or capped stone lintel. Several shaft-type apertures extended horizontally from the hearth into the kiln shaft. These "eyes" or flues regulated the draft and rate of burning within the kiln. A larger horizontal shaft beneath the draft holes facilitated removal of the burnt lime.

Behind the hearth at the bottom of the vertical kiln shaft was a lattice or grate of iron bars. This grate supported the weight of the stone and fuel charge. [24]

The kilns at the Eastburn-Jeanes site were all constructed of mortar and rough-hammered limestone quarried on the premises. The two largest kilns appear to have had a refractory lining of red sandstone, instead of the firebrick more common in late 19th century limekilns. The kilns were built to heights of 15 to 23 feet. The most interesting kilns are six adjoining hearths fronting on Pike Creek Road. No two of these six kilns are identical. This

fact suggests that when new kilns were added, design changes were made in hopes of obtaining greater efficiency.

On a bank of several commercial kilns it was common practice to construct a lean-to or shed roof across the front to protect attendants from the elements during their long watch over the burning process. [25] Supporting columns spaced at regular intervals for such a shed roof are evident at the Eastburn six-kiln group. In addition to shed roofs on the front, many kilns also had plank roofs across the top of the kiln shaft. These roofs kept out the rain and snow which would interfere with the burning process. They were removed when the kiln fire reached the top of the shaft. No evidence of such roofs on the Eastburn kilns remains. [26]

The Lime-Burning Process

The lime-burning process described below is typical of that which Eastburn and numerous small local operators practiced throughout the 19th century. Only after 1900 and the rise of large-scale quarries and kilns were these methods superseded.

Limestone was quarried on the Eastburn-Jeanes farms using sledges, hand drills, and presumably an occasional charge of black powder. Occasionally, underground springs were uncovered, which flooded the quarries. [27] Stone taken from below ground level proved the best for calcining. Large rocks, easily broken, were reduced to stones no larger than ten cubic inches. The limestone and cut firewood was then hauled in wagons to the kiln.

Charging the kiln involved first placing a layer of "lightwood," or kindling, at the bottom of the shaft below the iron grate. Next a cord or more of large softwood, then a layer of limestone, loaded from the top of the kiln. Small stone was placed toward the outer perimeter of the kiln shaft, with a larger stone toward the center to facilitate draft and even burning. Alternate layers of fuel and limestone were then piled upward through the boshes to the top of the kiln; the layers of wood became heavier, and those of stone lighter. Often stone was piled above the top of the kiln shaft and plastered over with mud or clay allowing for a center flue or draft hole. An elderly limeburner noted that it took two men 1-1/2 weeks or longer to charge a kiln the size of those on Pike Creek. [28]

Once fully charged, the kiln was ignited from beneath the

iron grate. As the limestone slowly burned and the contents of the kiln settled, new layers of stone and wood were added to the perpetual kiln from the top. The drawing of quicklime began once the limestone at the bottom of the kiln was fully burned (approximately six to eight hours). Using a long hook-shaped iron rake, burnt lime was taken out through the shaft below the iron grate. Drawing was repeated approximately every six to eight hours for as long as the fires continued to burn. [29]

The work of the limeburner was arduous at times; the kilns were kept burning continually throughout most of the year, and tending the kilns demanded a worker's full attention. The draft entering the kiln required constant regulation as winds shifted. Limeburners took turns tending the flues around the clock. [30] The lower the temperature and the longer the "burn," the better the quicklime produced. Consequently, a kiln's success depended heavily on the skilled craft knowledge of the experienced limeburner.

The yield of burnt lime from each kiln varied according to the capacity of the pot and the quality of the limestone. Generally, the burnt lime equaled approximately 60% of the charge of limestone by weight. [31] Though the perpetual kiln saved more fuel than the intermittent kiln, it still consumed vast quantities of firewood. A cord or more of wood (128 cubic feet) was required to burn 60 bushels of lime, each weighing approximately 80 pounds. [32] A kiln the size of those in Pike Creek Valley held a limestone charge sufficient to produce a total of 525 bushels of lime. Once started, the burning process could produce 300 bushels every 24 hours. [33]

After being raked from the kiln and cooled, the lime was packed in sealed casks of three-bushel capacity to await shipment. Bulk quicklime was frequently delivered by wagons for immediate, local agricultural use. [34]

For over 85 years, the Eastburn-Jeanes lime-burning industry served the builders and farmers in northern Delaware. Abandoned shortly after 1900, the limekilns of Pike Creek Valley remain as vestiges of this industry's importance to the economy of the region.

NOTES

[1] Martin S. Briggs, "Building Construction," in Charles Singer, et. al., A History of Technology (5 vols., Oxford, 1956), Vol. II, p. 407. Vitruvius noted the correct proportions of slaked lime (1 part) to sand (2 parts) for a good mortar.

[2] James C. Booth, Memoir of the Geological Survey of the State of Delaware (Dover, 1841), p. 182.

[3] Edmund Ruffin, An Essay on Calcareous Manures (2nd ed., Shellbanks, Va., 1835); Avery O. Craven, Edmund Ruffin, Southerner (Hamden, Conn., 1964), pp. 55-56.

[4] Albert Lowther Demaree, The American Agricultural Press, 1819-1860 (New York, 1941), pp. 65-67; Justus Liebig, Familiar Letters on Chemistry, ed. by John Gardner (New York, 1843), p. 42; Avery O. Craven, Soil Exhaustion as a Factor in the Agriculutral History of Virginia and Maryland, 1606-1860 (Urbana, 1926), p. 153.

[5] Warren S. Ely, "Lime Burning Industry, Its Rise and Decay in Bucks," A Collection of Papers Read Before the Bucks County Historical Society (Easton, 1917), Vol. IV, 71, 73-74. As experience with liming increased, 40 bushels per acre became standard practice.

[6] Francis A Cooch, Little Known History of Newark, Delaware and its Environs (Newark, 1936), p. 44. Most of the stone structures remain standing clustered along Pike Creek Road where they are still in use.

[7] Ibid., pp. 41-42.

[8] Booth, p. 13.

[9] S. M. Burnham, History and Uses of Limestones and Marbles (Boston, 1883), p. 58; Amos Long, Jr., "Pennsylvania Limekilns," Pennsylvania Folklife, XV, 3 (Spring, 1966), 28.

[10] Cooch, p. 43.

[11] Ibid.

[12] U. S., Congress, House, Documents Relative to the Manufactures in the U. S.: Returns from the State of Delaware (Washington, 1833), Vol II, pp. 740-741 (microfilm copy on deposit, Eleutherian Mills Historical Library, Greenville, Wilmington, Delaware).

[13] Long, 32.

[14] Manufactures: Returns from the State of Delaware, pp. 740-741.

[15] Cooch, pp. 43-44.

[16] Stevenson W. Fletcher, Pennsylvania Agriculture and Country Life, 1840-1860 (Harrisburg, 1950), p. 136; Manufactures: Returns from the State of Delaware, pp. 740-741.

[17] During the year 1849-1850, Joseph Eastubrn's kilns burned 580 tons of coal and only 60 cords of wood. See U. S. Census, 1850, Industry Schedule 5, Joseph Eastburn, Mill Creek Hundred, New Castle County, Delaware, Year ending 1 June 1850 (microfilm copy on deposit, Eleutherian Mills Historical Library).

[18] Cooch, p. 45.

[19] Roger L. Grindle, Quarry and Kiln: The Story of Maine's Lime Industry (Rockland, Maine, 1971), pp. 19-20.

[20] Charles Squarey, A Popular Treatise on Agricultural Chemistry (Philadelphia, 1842), p. 102.

[21] Essays on Hydraulic and Common Mortars, and on Lime Burning, trans. by J. C. Totten (Philadelphia, 1838), p. 1; Quincy A. Gillmore, Practical Treatise on Limes, Hydraulic Cements, and Mortars (New York, 1870), p. 138.

[22] Grindle, p. 20; Gillmore, p. 140.

[23] Long, 26.

[24] Data derived from on-site inspection of kilns. See also: Long, 26-27; Grindle, p. 35; Andrew Ure, A Dictionary of Arts, Manufactures, and Mines (Boston, 1853), p. 73.

[25] Long, 27.

[26] Ibid., 28.

[27] Ibid., 28; Cooch, p. 44.

[28] The description is a composite drawn from accounts of the process in Gillmore, pp. 141-143; Long, 29, 34; Grindle, pp. 35-36.

[29] Gillmore, pp. 143-144; Long, 30; Grindle, Ibid.

[30] Long, Ibid.

[31] Ibid.

[32] Grindle, p. 36; Gillmore, p. 143.

[33] Gillmore, Ibid.

[34] Cooch, p. 43.

SELECTED BIBLIOGRAPHY

Works dealing with the lime industry and the lime-burning process are all but nonexistent. The following works were found useful in the writing of this report:

Cooch, Francis A. Little Known History of Newark, Delaware and its Environs. Newark: The Press of Kels, 1936. The standard (if anecdotal) local history, and the only secondary work to treat the Eastburn-Jeanes complex.

Ely, Warren S. "Lime Burning Industry, Its Rise and Decay in Bucks." A Collection of Papers Read Before the Bucks County Historical Society. Easton: Chemical Publishing Co., 1917, pp. 69-74. Useful description of the industry in Pennsylvania, from which some parallels may be inferred for Delaware during a comparable period.

Gillmore, Quincy A. Practical Treatise on Limes, Hydraulic Cements, and Mortars. New York: D. Van Nostrand, 1870. Contains useful data on kiln construction and the burning process.

Grindle, Roger L. Quarry and Kiln: The Story of Maine's Lime Industry. Rockland, Maine: Roger L. Grindle, 1971. Well-illustrated volume dealing with large commercial lime operations in the 19th century. Again, parallels inferred.

Long, Amos, Jr. "Pennsylvania Limekilns." Pennsylvania Folklife, XV, 3 (Spring, 1966), 24-37. Though antiquarian, this is by far the most detailed treatment of kiln construction and lime burning encountered.

U. S. Census. 1850. Industry Schedule 5: Joseph Eastburn, Mill Creek Hundred, New Castle County, Delaware, Year ending 1 June 1850. Microfilm copy on deposit, Eleutherian Mills Historical Library, Greenville, Wilmington, Delaware. Manuscript census of manufactures data, contains a wealth of detailed economic and technical data.

U. S. Congress. House. Documents Relative to the Manufactures in the U. S.: Returns from the State of Delaware. Washington, 1833, Vol. II, pp. 740-741. Microfilm copy on deposit, Eleutherian Mills Historical Library. The returns of Abel Jeanes and Joseph Eastburn compiled in 1832 reveal much about the extent of their lime operations at that time. Of inestimable value in the writing of this HAER report.